The Stimulus-Error, "Equivocal Correlation" and Perceptual Constancy

By: Mazviita Chirimuuta

Boring (1921, 451) writes that, "[w]e commit the stimulus-error if we base our psychological reports upon objects rather than upon the mental material itself, or if, in the psycho-physical experiment, we make judgments of the stimulus and not judgments of sensation." Titchener (1910) and Boring (1921) both argue that the stimulus-error is indeed a serious methodological pit-fall. While some of the theoretical suppositions motivating their arguments—a rigid separation of sensation from perception, and their characterization of psychology as the measurement of purely mental phenomena—are currently unfashionable, one aspect of the stimulus-error debate is of perennial importance to psychophysics and the psychology of perception. This is the idea that the stimulus-error is a source of unwanted variability in subjects' responses, but one which can be controlled for by careful training of subjects and judicious use of experimental instructions. In this paper I propose first to discuss Boring's presentation of the problem of unwanted variability ("equivocal correlation") in haptic perception and then to examine the issue in relation to recent experiments on lightness and colour constancy. Discussion of the stimulus-error sheds light on the ongoing debate about how best to measure constancy phenomena and reveals some of the conceptual fault-lines within perceptual psychology past and present.

In the concluding section of his 1921 article, Boring makes the case that the stimulus-error is not exclusively the concern of adherents to the "psychology of datum" (i.e. those using introspectionist methods), but is also of concern to the "psychology of capacity" (i.e. behaviourism). He writes that: the effect of the "stimulus-error,"s from the point of view of a psychology of capacity, is … to render the correlations between stimulus and response equivocal and thus to jeopardize the rigor of conclusion that science demands. (Boring 1921, 465-6)

His primary example is the measurement of the tactile two-point threshold—the measurement of the minimum distance between two pressure points on the skin which reliably gives the impression of two separate stimuli. In such an experiment the psychologist of capacity is only concerned with the stimulus and verbal report. However, Boring observes, the relationship or "correlation" between stimulus and report is variable ("equivocal") due to differences in intermediate factors of attention and "attitude" or criterion, i.e., whether the subject's report reflects her sensory state or her judgment of the stimulus (see Figure 1). As Boring (1921, 470) writes, "the failure to control the attitudinal factor…results perforce in an equivocal determination of these responses, which is nothing more nor less than a 'stimulus-error' ".

Boring's concerns about the effects of shifting response criteria were in some respects met by the development of signal detection theory, a set of techniques used by psychophysicists to estimate the discriminability of stimuli regardless of the subject's response bias. On the other hand, some well known experiments on colour constancy have exploited, to good effect, response variability due to the difference between stimulus and sensation reports.

Colour constancy is often characterised as the stability of colour appearances (the hue and saturation that objects appear to have) despite changes in ambient illumination. However, changes in illumination do cause noticeable changes in colour appearances so it is open to debate whether colour constancy is better characterised as the ability to match coloured stimuli across changing illumination. Arend and

Reeves (1986, 1743) criticised an earlier study by McCann et al. (1976) on the basis that the task performed by their subjects was open to either interpretation. In their own study, Arend and Reeves gave their subjects two different kinds of instructions: either to match hue and saturation or to match stimuli so that they looked as if made from the same colour paper. Arend and Reeves report that in the first task (sensation reports) subjects showed little colour constancy, whereas for the second task (stimulus reports), subjects showed approximate colour constancy.

One might conclude that while Boring and Titchener were right to draw attention to the stimulus-"error" as a source of response variability, their strictures against stimulus reports are unfounded; indeed, it may be the case that certain perceptual phenomena, like colour constancy, are better measured through stimulus reports. However, that would be to ignore an on-going controversy about whether all such stimulus reports are genuinely visual and not, rather, judgements or inferences made by subjects about the likely source of stimulation.
For example, Robilotto and Zaidi (2004) performed a series of experiments on lightness constancy in which subjects were required to determine which out of four stimuli presented under different illumination conditions (see Figure 2a) was the odd one out due to a different surface lightness (see Figure 2b for correct answer).

Now even though Robilotto and Zaidi's task instructions were such as to prompt a stimulus report, significant response variability was still observed. The majority of subjects' data was consistent with them using a strategy based on sensation matching, whereas two subjects' data suggested that their responses were based on their inferences about the likely stimuli rather than perceptual experience per se. Robilotto and Zaidi (2004, 792) write that, "[i]ndividual differences thus are likely to be due to attempts to infer a nonsensory quality, rather than due to the particular task or instruction." What is striking is that Robilotto and Zaidi's analysis rests on a robust sensation-perception distinction, and a suspicion regarding non-sensory reports, that is controversial amongst constancy researchers (Chirimuuta 2008, 578). Thus, I will argue, in this modern iteration of the stimulus-error debate we come full circle back to Boring and Titchener's initial concern to demarcate the appropriate phenomena for the psychology of vision.

References:
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